DOCUMENT RESUME

ED 158 719 IR 006 172

AUTHOR Bennion, Junius L.; Schneider, Edward W.
TITLE Interactive Video Disc Systems for Education.
INSTITUTION Brigham Young Univ., Provo, Utah. Div. of Instructional Research, Development, and Evaluation.
PUB DATE 30 Oct 75
NOTE 19p.; Paper presented at the Society of Motion Picture and Television Engineers Conference (Los Angeles, California, October 3, 1975); For related documents, see IR 006 175-176

EDRS PRICE MF-$0.83 HC-$1.67 Plus Postage.
DESCRIPTORS *Computer Assisted Instruction; Display Systems; Educational Technology; *Individualized Instruction; Instructional Innovation; Instructional Media; *Technological Advancement; *Video Cassette Systems
IDENTIFIERS TICCIT Computer System; *Videodisc Recordings

ABSTRACT

The basic design of the videodisc technology, especially the three features of the freeze frame, electronic address, and fast random access, makes possible the creation of a new audiovisual delivery system that has revolutionary applications for education in individualized interactive instruction. In addition to the linear playback mode for home movie and television rerun entertainment, the optical videodisc is capable of providing branching because of random access and electronic addressing capabilities. The system is also able to accommodate many psychological procedures for enhancing learning, such as the capability of inserting questions in still frames or aural modes at any point. Special features offered by the video disc system which make it more flexible than TICCIT are motion control, greater audio capabilities, and the lack of need for an external computer. (Author/CMV)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

- ED158719

INSTITUTE FOR COMPUTER USES IN EDUCATION

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
NATIONAL INSTITUTE OF EDUCATION

THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL NATIONAL INSTITUTE OF EDUCATION POSITION OR POLICY

INTERACTIVE VIDEO DISC SYSTEMS FOR EDUCATION

Junius L. Bennion
and
Edward W. Schneider, Ph. D.

Brigham Young University

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY

Harold H. Hendricks

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC) AND USERS OF THE ERIC SYSTEM."

September, 1975

Prepared For Presentation at the
Society of Motion Picture and Television Engineers
Conference

Los Angeles, California

October 3, 1975

DIVISION OF INSTRUCTIONAL RESEARCH, DEVELOPMENT
AND EVALUATION
Brigham Young University
Provo, Utah

IR006172

Interactive Video Disc Systems For Education

by

Junius L. Bennion
and
Edward W. Schneider, Ph.D.

The emerging video disc technology promises to be one of the most revolutionary developments in the history of entertainment and education since the invention of the motion-picture process (Vance, 1975). This statement in a recent popular publication is typical of the expectations and enthusiasm now building over the optical video disc system being developed by MCA (Music Corporation of America) and Philips. The video disc is expected to be introduced to the public in the next year. The first program materials to be distributed will be popular movies that will use a linear playback mode. Because of the low cost of both the players and the video discs the home market for movies will grow rapidly, and video disc players will become commonplace in the next few years.

In addition to the linear playback mode the optical video disc is capable of providing interactive branching because of random access and electronic addressing capabilities. These capabilities will permit the development of an important new series of delivery systems for education when these features are fully utilized. To see how these features can be used for interactive educational delivery systems we must first review some of the basic design parameters of the video disc technology.

The optical video disc technology is a new communications media that can provide 30 minutes of color television programming with multiple audio tracks from a video disc that is 12 inches in diameter and only .01 inches thick.

The video disc player recovers video signals from a thin plastic disc for insertion into the VHF antenna terminals of a standard television set. Although other techniques have been developed only the optical laser system will be described in this report because of its greater potential for interactive operation. (For a progress report on video discs the reader is referred to the July, 1974, Journal of the SMPTE and to the May, 1975, Educational and Industrial Television.)

The optical video disc master is created by exposing a revolving metal-coated glass plate with a modulated laser beam. As the disc rotates at 1800 revolutions per minute the laser burns through the metal coated surface and forms a track about one micrometer wide. The laser is alternately turned on and off by the combined video and audio signal resulting in pits on the disc surface. The optical laser system is moved across the rotating disc by a lead screw to create a spiral pitch that produces about 18750 tracks per radial inch. From the master disc submaster discs are made that are then used to press copies into mylar or plastic. These replicated discs are pressed in a manner similar to the techniques now used for producing audio records resulting in very low cost for duplication. After pressing, the disc is given a metalized coating to make it reflective and then it is coated with a clear plastic protective layer.

A low powered laser with appropriate mirrors and microscope optics is used in the video disc player to recover the modulation originally recorded on the master video disc. After detection the modulated signal is amplified and then inserted into the VHF antenna terminals of an unmodified television

receiver. Through the use of servo circuits the laser beam is made to follow the spiral track of recorded information in a manner similar to that of a phonograph needle on an audio record. However, because a light beam is used there is no physical contact, and consequently no wear occurs. The same servo tracking circuitry can also be used to cause the laser beam to retrace the same track continually thus stopping the motion on the TV screen in the "freeze frame" mode.

Each revolution of the disc creates a single TV frame. Thirty TV frames are created each second to produce motion. Broadbent (1974) has demonstrated the capability of encoding each frame with a coded serial number that can be located by an electronic search technique. Thus, any frame out of the 54000 frames on a 30 minute video disc can be located in a few seconds. This unique feature makes it possible to provide a fast random access system which will have many unique applications. We will now discuss one of these applications for education.

Three features of the video disc system, i. e., the freeze frame, electronic address, and fast random access, make possible the creation of a new audio-visual delivery system that has applications for individualized interactive instruction. By adding the capability to automatically change from motion to freeze frame mode it is possible to interlace motion sequences with still frames. For example, the video disc could show a motion sequence that teaches a concept, then test for comprehension by giving a question on a still frame that would appear automatically. The student would then be required to answer the question by inputting his answer through a keyboard. A correct

answer would branch the student to a positive feedback frame, or an incorrect answer would result in a negative feedback frame being shown. The video disc itself can contain vast numbers of special digital codes in addition to the serial number codes for each frame. These codes can be continually unloaded from the video disc into a local memory or microprocessor that is part of the keyboard. A character generator, also a part of the keyboard, can be used to display the students keyboard responses on the TV screen. An interactive video disc system embodying these features is shown in figure 1.

- - - - - - - - - - - - - - - - - -

Insert Figure 1 about here

- - - - - - - - - - - - - - - - - -

The interactive video disc system can be located anywhere where 60 cycle 120 volt ac power is available. Each terminal can be operated as a stand-alone system because the video disc provides storage for all of the instructional material and the digital codes needed for interactive operation. The video disc system does not require an external computer. Although some functions such as student records and advice that are provided by some computer assisted instruction (CAI) systems may be hard to implement, the main load of instruction could be provided by this interactive video disc system thus extending interactive instruction into homes and schools for continuing education and open university applications.

The details of one suggested configuration for a video disc keyboard are shown in figures 2a and 2b. Many other configurations are possible.

The center alpha-numeric keys are similar to keys found on an electric typewriter. The keys to the left side provide the student with five keys for motion control, four keys for cursor control (for positioning responses on the TV screen), exponent and subscript keys, a "Mark" key, and the "Enter" key. The motion control keys permit the student to stop a motion sequence at any time; back up, or go forward in slow motion or in fast motion. This feature enables the student to study motion sequences in a variety of ways which are either not possible or are not convenient with any other type of motion media.

- - - - - - - - - - - - - - - - - -

Insert Figures 2a and 2b about here

- - - - - - - - - - - - - - - - - -

The keys located to the right of the center set of alpha-numeric keys are designated as the "learner control keys" and are designed to function in a manner similar to the learner control keys in the TICCIT system. TICCIT stands for Time-shared Interactive Computer Controlled Instructional Television; a CAI project funded by the National Science Foundation. The MITRE Corporation and Brigham Young University are jointly working on this project. (Volk, Mason, & Zraket, 1974).

The TICCIT system is based on the concept that it is possible to separate strategy from content; that it is possible to view the way students are taught independently from what is taught. This concept is implemented partially through the use of these learner control keys. (Bunderson, 1973, O'Neal, 1973).

Learner control courseware for TICCIT (and eventually for the interactive video disc because of its similarity to TICCIT) is based upon Pask's (1969) multilevel model of student-system communication and Merrill's (1973) taxonomy of instructional variables. The multilevel model of student-machine communication developed by Pask has been used as a basis for providing three levels of discourse that are implemented in TICCIT (See Volk, Mason, & Zraket, 1974, pp 26-28). These levels are:

Level 0- Computer presents information and asks questions; Student makes pacing responses and answers questions.

Level 1- Level 0 plus capability for student to command computer relative to strategy (defined primarily as sequence within a well-structured set of instructional components).

Level 2- Levels 0 and 1 plus ability of student and computer to converse (in a highly structured way) about high level concerns (strategy, attitudes, modifying contingencies, etc.). The student can take action to modify his processes of controlling the system, using control keys and commands.

The lowest level of discourse is implemented on TICCIT within files of instances where students may examine worked examples accessed by the EXAMPLE key or obtain practice in solving problems by using the PRACTICE key. The student may examine the appropriate concept or rule by pressing the RULE key. This level of discourse is typical of the more conventional "tutorial CAI" systems.

The next level of discourse is implemented through the keyboard which provides the student with the capability to command the computer relative to strategy. The student may select difficulty levels by using the EASY and HARD keys or he may obtain elaboration with the HELP key. He may also SKIP, REPEAT, or go BACK as he deems necessary.

The highest level of discourse involves the ability of the student to obtain ADVICE through the Advisor program and to observe "status displays" concerning his current standing and progress. These displays are available at various levels in the instructional hierarchy (i. e., segment, lesson, unit, and course) by depressing the MAP key which serves two functions: (1) as an advanced organizer, and (2) as a progress display board. The OBJECTIVE key also provides advanced organizers by providing instructional objectives at each level of the hierarchy.

The first two levels of discourse can be implemented on the video disc by the use of digital codes that interpret keyboard inputs and by the use of branching points provided by question and menu frames. The third level of discourse will require record keeping and logical processing that can be accomplished at greater cost and complexity by using more memory storage and some additional microprocessors in the keyboard. Recent advances in integrated circuitry have reduced component size and cost, and this trend is continuing thus making these features possible to attain.

With the new advances in CAI it is expected that students will develop learning strategies that will foster greater motivation, growth and responsibility. The expectations for the interactive video disc are similar. So far

we have pointed out several similarities between TICCIT and the proposed interactive video disc system. In addition, we should point out three limitations of TICCIT: (1) no motion displays (2) limited audio and (3) a maximum separation from computer to terminal of 1500 feet of coaxial cable. The interactive video disc system can overcome all of these limitations. In addition, because each video disc is only required to provide instruction for a single student, it is possible to vary the instructional parameters in ways that would not be possible on a CAI system. Any lesson or, for that matter, a small part of any segment could employ a different instructional strategy. For example, if it were desired some of the learner control keys could be disabled and a full systems control could be implemented that would be similar to programmed instruction techniques. This is easily accomplished by altering the interpretative keyboard codes to lock out certain functions. Other changes in instructional strategy could be implemented as specified by the author and the instructional psychologist.

For authoring materials to be used at secondary or higher education levels, the same premises discussed by Merrill (1972) apply: (1) Content and instructional strategy are independent phenomena. (2) Most courses involve only two types of content-concepts and operations. (3) Concepts and operations can be represented at two levels of abstraction-generalities and instances. (4) Most courses involve only four levels of behavior-discriminated recall, classification, rule using, and rule finding, and, (5) Instructional strategies should revolve around rule using or rule finding tasks based on mastery models derived from needs and goals.

Techniques for analysing content and developing instructional strategies are adequately discussed by Merrill (1972), Gagne (1970) and others. These techniques are directly applicable to authoring materials for the interactive video disc system and will not be discussed in this report. However, a simple model of some of the instructional parameters that the video disc system can accomodate is presented in figure 3. This model is a three dimensional matrix showing type of instruction vs difficulty vs elaboration. Three types of instruction are supported by the learner control keys; RULE, EXAMPLE and PRACTICE. Three levels of difficulty are provided for each type of instruction by the keys EASY and HARD, and by the policy of having the student always enter each type of instruction at the medium level. Elaboration is provided by the HELP key prior to the student responding to a question, and knowledge of results (KOR) is provided by the feedback frames after the student has responded. In addition to KOR the feedback frames may include additional elaboration that is based upon error factor analysis. Advanced organizers are provided by the MAP and OBJECTIVE keys and by a series of mini-lessons that are available for review prior to entering the main instructional material. The need for advanced organizers is discussed by Ausbel (1967).

- - - - - - - - - - - - - - - - - -

Insert Figure 3 about here

- - - - - - - - - - - - - - - - - -

Information files for the video disc system can be authored by techniques similar to those used for the TICCIT project using a team approach. Division

of labor is possible between subject matter experts, instructional psychologists and other personnel such as assistant authors, packagers, TV or film cameramen, and secretaries. However, in addition to the authoring of still frames a description of motion sequences must be provided in storyboard format for the guidance of the TV or film cameramen. Also, a series of forms cataloging the appropriate addresses and interpretation of keys must be specified in order to tie the system together and make the learner control keys move the laser read head to the right position on the disc. These are all mechanical and bookkeeping details that are fairly straightforward once the subject matter expert and the instructional psychologist have decided on the major strategies to be implemented.

The interactive video disc system is able to accomodate many psychological procedures for enhancing learning. For example, the use of inserted questions can be handled very easily by using still frames with such questions inserted into either the generalities or examples. At any point a motion sequence can be interupted by a freeze frame containing a question that requires the student to respond or to think about and thus to more easily learn the material just presented. Multiple choice, fill in the blank, or other types of questions may be used. It is possible to present questions and feedback in both the aural and visual modes. The conversational style made possible by the widespread use of audio is expected to help in maintaining attention and interest as the student uses the rule, example and practice files and receives feedback. Of course, audio can not be provided with still frames unless a digitized audio storage capability is added. With the vast number of frames avail-

able this is a distinct possibility.

The video disc has room for many inserted questions. For example, if only one minute of motion were transformed into still frames, this would provide 1800 still frames that convert to five hours of instruction when viewed for an average of ten seconds per frame. Other ratios of study time vs the number of minutes devoted to still frames are given in figure 4. Notice that if the 30 minute video disc were devoted entirely to still frames it would take a student 150 hours to complete a single disc!

- - - - - - - - - - - - - - - - - - - -

Insert Figure 4 about here

- - - - - - - - - - - - - - - - - - - -

It is possible to provide testing on the interactive video disc terminal by adding a recording capability. Digital records of student responses to test questions could be recorded on a magnetic oxide coating at the center of the disc or on an auxilary cassette recorder. After completing a lesson the video disc test records would be returned for grading. These records could then be processed at a computer center that would perform automated analysis and provide computerized printouts for use by the student and the instructor on a timely basis. Such records may not assist the student in the learning task, but are essential for awarding credit.

The flexibility in locating video disc terminals and the absence of scheduling problems so characteristic of instructional video programming make the interactive video disc system attractive for use in secondary and higher educational institutions. It is also possible to extend educational opportu-

nities to off campus locations and greatly expand the continuing education and open university concepts that are now gaining momentum throughout the world.

New developments in computer technology and integrated circuitry are reducing the size and cost of components and increasing the amount of processing that can be performed. It is now becoming feasable to perform the functions described above for testing and interactive instruction by designing interactive keyboards with integrated local memories, microprocessors, and character generators. Compatable editing equipment with the capability for inserting single frames and appropriate digital codes into motion sequences must also be developed. No requirement for such precise editing techniques has existed prior to the development of the interactive video disc system. Perhaps the freeze frame capability itself can be utilized to transfer a single frame from a video disc player to the master video disc while both are operating in the freeze frame mode. Undoubtedly, computer editing techniques will be utilized to save time and to lower the costs of production.

The interactive video disc system offers opportunities to combine research in psychology and education into new delivery systems for interactive, individualized learning. We share the viewpoint with Cuppens and Ducot, (1974) that these systems may have a great impact on the educational environment in the near future.

A discussion of the costs of providing interactive instruction using video discs is in order. We shall discuss the hardware costs first and then the courseware costs. The student terminal (figure 1) consisting of a color TV, a video disc player and an interactive keyboard will probably range in price from $1500 to $3000 depending upon the model and size of the TV and the complexity of the keyboard and the associated electronics. All three components are expected to have very long lifetimes; hence the cost per hour due to the hardware will be relatively low compared to the cost of the courseware. For example, TV sets are commonly warranteed for one to two years and often operate without major repairs for five years. If operated for 20 hours per week for 5 years the running time would be 5200 hours. MCA has indicated (Broadbent, 1974) that the laser used for playback can be expected to operate for 9000 hours. If the other components also operate without major expense for maintainence for 5 years then the cost of instruction due to the hardware would be in the order of 30 to 60 cents per hour.

The following cost model applies to the cost per hour of instruction for interactive video disc courseware.

$$\text{Cost of Instruction per Hour (dollars)} = \frac{1}{\text{Hours of Instruction}} \left[\frac{\text{Development Costs}}{\text{Market Size}} + \text{Prod. Costs} \right]$$

The ratio of still frames (sf) to motion frames (mf) and the costs for producing still frames (sfc) and motion frames (mfc) are related to the hours of instruction and the development and production costs in the following equation which serves as our model for calculating the curves in figure 5.

$$\text{Cost/Hr.} = \frac{1}{.5\left(1 - \frac{\%sf}{100}\right) + \frac{\#sf}{720}} \left[\frac{(\#sf)(sfc) + (\#mf)(mfc) + 500}{\text{Market size}} + 1\right]$$

The assumptions implied in the above cost model are the following:

1. Each still frame is viewed for an average of 10 seconds (or 360 frames per hour).

2. Each still frame is supported by one other frame that is used for digital codes, therefore a total of 720 frames are needed for one hour of still frame instruction.

3. The production costs for a single video disc are $500 and drop to $1.00 per disc for large quantities according to the following:

$$\text{Production Costs} = \frac{\$500}{\text{Mkt. Size}} + \$1.00$$

If we assign the following development costs for still frames (sfc) and for motion frames (mfc) we can calculate hourly costs of instruction for a variety of market sizes. We have done this for market sizes of 100, 1000, 10000 and 100,000 video discs, using sfc = $10 and mfc = $0.20, in Figure 5.

- - - - - - - - - - - - - - - - - - - -

Insert Figure 5 about here

- - - - - - - - - - - - - - - - - - - -

As observed in figure 5 the cost of one hour of interactive instruction is related to the number of video discs produced and to the percent of the disc devoted to still frames. It is interesting to note that when more than 20% of the disc is devoted to still frames the cost of instruction per hour is essentially constant. This is due to the fact that as the costs of producing interactive video discs increase the length of instruction also increases and the net result is that the cost of instruction per hour remains almost constant.

An interactive video disc with 20% still frames would provide 16 hours of instruction whereas one with 80% still frames would provide 60 hours of instruction. Thus the type of content and the length of instruction desired can be manipulated over wide ranges without changing the hourly cost of instruction.

The calculations represented in figure 5 are for a single one-time use of the disc. Of course, if the disc is used many times as in an educational setting then the cost of instruction due to the cost of video disc courseware would decrease accordingly. Thus if only 100 discs were produced but these discs were each used 100 times the hourly cost of instruction would decrease to essentially the same curve as that for 10,000 discs. (ie approximately 75¢ per hour). Correspondingly, if 1000 discs were produced and used 100 times each, the hourly cost for instruction would be reduced to less than 10¢ (for 20% or more still frame usage). Of course, these results are based on some rather crude cost figures that need to be refined, but they indicate the definite possibility of high quality interactive instruction at very low cost when the production run is large and/or when each disc is used many times. No other interactive instructional system that provides motion, color and audio is capable of operating at such low costs. The flexibility in scheduling and location plus the high quality of instruction and low cost per hour that appear to be realizable with the interactive video disc system may permit this new technology to have a great impact on the educational environment in the near future.

REFERENCES

Ausbel, D. P. A cognitive-structure theory of school learning. In L. Siegel (Ed.), Instruction: Some contemporary viewpoints. San Francisco: Chandler, 1967. Pp. 207-257.

Broadbent, K. D. A review of the MCA DISCO-VISION system. Journal of the Society of Motion Picture and Television Engineers, 1974, 83, 554-9.

Bunderson, C. V. The TICCIT project: Design strategy for educational innovation. ICUE Technical Report No. 4, Institute for Computer Uses in Education, Brigham Young University, Provo, Utah. September 1973.

Cuppens, E., & Ducot, C. Future education and the new technical means. ACTA Electronica, 1974, 17, 241-270.

Gagn'e, R. M. The conditions of learning. (2 nd ed.) New York: Holt, Rinehart & Winston, 1970.

Merrill, M. D. Content and instructional analysis for cognitive transfer tasks. Working Paper No. 40, Division of Instructional Services, Brigham Young University, Provo, Utah. Dec. 5, 1972.

Merrill, M. D. & Boutwell, R. Instructional development: Methodology and research. In (Ed.) Review of Research in Education, AERA, 1973. (Also Instructional Research and Development Department, Working Paper Series # 33, Brigham Young University, Provo, Utah. $2.50).

O'Neal, F. Learner control of instruction: requirements and potentials. ICUE Technical Report No. 2. Institute for Computer Uses in Education, Brigham Young University, Provo, Utah. August, 1973.

Pask, G. Strategy, Competence and conversation as determinants of learning. Progressive Learning and Educational Technology, 1969, 6.

Vance, A., MCA, Philips join forces: Video-disc player for any TV set now targeted for '76. Popular Photography, May, 1975.

Volk, J. L., Mason, W. F., & Zraket, C. A. An overview of the TICCIT program. The Mitre Corporation, Washington, D. C., January 1974.